PATENT SPECIFICATION

942,754

DRAWINGS ATTACHED.

942,754

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COMPLETE SPECIFICATION.

Improvements relating to the Aeration of Water.

We, PERMA-PIER, INC., a Corporation organised and existing under the laws of the State of Illinois, United States of America, of 8333 Niles Center Road, Skokie, Illinois, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with the aeration of water.

In inland lakes and seas, lack of oxygen in the water is a serious problem in winter time. Even large lakes freeze over completely and ice on the surface keeps air away from the water. Thus, fish use up the oxygen dissolved in the water and suffocate. This "winter kill" of fish is quite common in many areas and is most undesirable from the standpoint of fishermen, from a conservation standpoint, and from the standpoint of disposition of the dead fish when the ice thaws. Lack of sufficient aeration of water is also a problem in aquariums and in swimming pools where lack of oxygen allows undesirable organisms to grow.

Even in summer, fish die due to eventual lack of oxygen in still water, especially as decaying vegetation uses oxygen. This leads to a consequent loss of business for those wishing to attract fishermen.

In some cases artificial aeration is resorted to, and air is pumped through a nozzle or the like and is bubbled into the water. However, the bubbles thus produced are fairly large and rise to the surface without being dissolved to any great extent.

The aim of the present invention is to provide an improved method of aerating water, and according to the invention this method comprises producing a current of water beneath the surface and introducing air taken from above the surface into the current thus produced, in which the rate at which the air is introduced into the current is maintained sufficiently low for the greater proportion of the air to be contained in the current of water as finely-divided bubbles of air which dissolve in the water to a substantial extent, and in which the current of water is produced in the form of an unconfined "shaft" of moving water taken from a point well below the surface of the water and no higher than the level at which the current is produced.

The invention extends to apparatus for carrying out this method, and two examples of apparatus in accordance with it will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a side view, partially in section, showing one form of the apparatus installed in a lake;

Figure 2 is a perspective view of part of the apparatus shown in Figure 1;

Figure 3 is a top view showing the aeration of a small lake;

Figure 4 is a schematic view of another form of apparatus; and

Figure 5 is a top view of the apparatus shown in Figure 4.

The apparatus shown in Figure 1 comprises a pumping or aerator unit 18 which rests on the bottom 12 of a lake 14 and has a housing 20 made of corrosion-resistant sheet metal. The housing is open at the bottom and also has apertures 22 to admit water to its interior. The housing supports a pump 24 having an intake strainer 26, and the pump is driven by a sealed fractional horsepower electric motor 28 of a type readily available in commerce. Operation of the motor is preferably intermittent, and

can be controlled manually from the shore or automatically by a timer 30 mounted on the motor. Alternatively, a device for testing the condition of the water in the lake could be used to control operation of the motor and pump.

The outlet 32 of the pump is connected to a header 34 having a number of risers 36 extending up from it. Each of the risers 36 is connected to a venturi-type nozzle 38, and although these nozzles are shown as being disposed parallel to one another, they could be arranged so as to diverge from one another. Where a parallel arrangement is selected, the nozzles could all be mounted on a header positioned above the housing 20, but it is generally preferred to mount the nozzles individually, as shown in Figure 2, to allow them to be aimed. The number of nozzles provided depends on the horsepower, depth, and required rate of flow.

A float 40 is disposed above the nozzles 38 and has a depending flexible tube or hose 42 connected at its lower end to a header 44 which is in turn connected to the venturi nozzles 38 by tubes 46. The upper end of the hose 42 is above the surface 16 of the water at 48 and the float is provided with air inlet holes 50. Thus, where the water from the pump is discharged from the venturi nozzles 38, air is drawn in through the hose 42 and is mixed with the water in the nozzles for discharge as horizontal streams of water and fine bubbles as shown at 52. A few large bubbles also pass through at 54, and quickly rise substantially vertically to the surface as with conventional aerating equipment.

Water taken into the pump 24 is picked up substantially from the bottom of the lake, i.e. below the level of the nozzles 38 which produce the current of water. Water at the bottom is more dense than water above this level, and since water density varies with temperature, the water at the bottom will be at a different temperature than the water at the level of the nozzles 38. Hence, the water discharged from the nozzles 38 will not readily mix with the water into which it is discharged but will continue to move horizontally a substantial distance as a discrete stream or number of streams. Thus, the air bubbles brought into the water by the venturi nozzles 38 are spread out over a large area, instead of being all bubbled up at the same location. Accordingly, a greater quantity of water is aerated. Furthermore, the venturi nozzles inherently tend to bleed air into the water streams as exceedingly finely-divided bubbles of about pin-head size. These small bubbles dissolve much more efficiently than large bubbles, partly because small bubbles present a larger surface area than do large bubbles for a given volume of air. Internal turbulence of the discharged stream also aids in dissolving the air bubbles in the stream. When the bubble size is reduced below a certain size or diameter, the bubbles will tend not to rise to the surface, but due to surface tension as affected by temperature, pressure due to depth and other factors, the bubbles will stay in suspension. Thus, the finely-divided bubbles will reduce the over-all density of the unconfined current shaft, causing the shaft to rise to the surface by convection due to the weight of the water above it.

In an actual installation, the stream of fine bubble-laden water has been observed to extend out nearly horizontally, rising very slightly due to the buoyant effect of the air bubbles, for a distance of 8 to 10 feet with no bubbles rising to the surface except the few large ones at 54. Substantially all of the air bubbles are dissolved over a large area. In relatively small lakes, continued operation of the unit may set up a continuous circulation of water as shown at 56 in Figure 3 whereby all of the water is aerated without the need for depending or diffusion or multiple installations. Obviously, several units may be installed in larger volumes of water if desired. However, one small unit as described above has been found adequate for the aeration of 200,000 cubic feet of water. A motor of $\frac{1}{3}$ horsepower is generally considered adequate for handling up to five or six nozzles 38.

In instances when it is desired to maintain the surface 16 free of ice 17, the nozzles may be tilted up as indicated in dashed lines in Figure 1. The water taken from the bottom and discharged from the unit 18 will nearly always be above freezing temperature, since even in the coldest weather inland lakes do not freeze over more than a few feet down. Additionally, water is densest at about 39° F. and the dense water at the bottom may thus be expected to be substantially above freezing. This relatively warm water in the water-air stream 52 reaches the surface and spreads out as a warm, rather thin, surface layer or pool 58. This layer either prevents the formation of ice 17, or melts ice already in existence. Thus, simultaneously, the lake is artificially aerated and kept free of ice (at least in predetermined areas) for natural aeration and for navigation and elimination of ice damage to boats, piers and other structures.

In otherwise frozen-over lakes, fish have been found to gather from miles around in an aerated, ice-free area as just described. In warmer climates or in summertime, when ice is no problem, aeration as heretofore described (horizontal discharge) has been found to cause fish to increase greatly in number and to grow to a substantially larger size.

As will be apparent, submersion of the entire apparatus, except for the float, protects the apparatus from the elements. The amount of power necessary to run the unit is small, whether simply for aeration, or whether also for ice control, and the cost and installation is not great. The height at which the water is discharged may vary according to individual installation conditions.

Figure 4 shows a modified form of apparatus 60 which includes a motor 62 mounted on legs 64 and driving a propeller 66, the electric leads not being shown. An air line 68 is connected to a float 70 or it may be connected to a dock or to the shore. The air line is controlled by a valve 72 which is located at any point, and the line 68 is connected to the unit 60 with one or more air outlets directly next to and on the low pressure side of the propeller 66 so that the velocity of the water moving past the air outlets reduces the pressure in the air line to draw air down. The propeller is rotated at a relatively high speed and is directed to set up a column or shaft 73 of unconfined moving water which will have finely divided bubbles in it, the water for the column being drawn from a level no higher than that at which the water is impelled by the propeller. The valve regulates the bubble size and the finely divided bubbles are thoroughly mixed into the free column. The unit also may be directed upwardly, as at 74, to free the surface of the water from ice.

As shown in Figure 5, the unit 60 may be oscillated or reciprocated through a given sector 76. The extent of the sector may depend upon the particular installation, and the unit may revolve through 360° before reversing. Alternatively, it may be completely rotary. By oscillating the unit, the low density current shaft will create a low density stratum. The speed of oscillation may be governed by the rate of convection rise of the stratum so that the shaft will create a stratum by a given number of strokes before perceptible upward movement takes place. The speed of oscillation affects the shafting distance so that if it is desirable to only open up the ice close to the unit, a more rapid oscillation should be employed, whereas a slow oscillation would cause the shaft to flow much farther from the unit. Also, oscillating will serve to mix air and water more effectively.

It therefore follows that, by a combination of slow oscillation and air restriction for very fine bubbles, the water shaft can be made to extend a greater distance. By a combination of rapid oscillation and larger bubbles, the water shaft will be confined to a much smaller area.

Another variable controlling the water shaft behaviour is the propeller pitch which may be pre-set for the desired water flow velocity.

The unit may be regulated so that both large and small bubbles are released, the greater proportion being small bubbles. The large bubbles will rise relatively close to the unit and will keep the surface above the unit ice free by mechanically lifting the warmer water. The aerated shafting will de-ice the somewhat more remote areas, and the combination of the two will keep an extensive area ice-free. The unit may be operated continuously or cycled on any given off and on cycle or pulsated.

By throttling the inlet, the bubble size can be observed, and the throttle may be set when the bubbles are small enough so that they will stay in suspension and will not rise rapidly. The precise bubble size necessary cannot be accurately determined at the present time, other than by a trial and error method.

If necessary, hydrogen or another inexpensive lightweight gas or fluid may be introduced into the current shaft so as to reduce its density. Also, the unit may be disposed in deeper water and directed slightly upwardly into shallow water, under a dock, for example, with a sufficient arc of oscillation to keep a given area around the dock ice-free.

When only aeration is required, as in summer, the oscillation may be stopped. The unit may also be operation with aeration only, which would produce a long, narrow, ice-free area.

The unit also may be directed upwardly to form a crown at a given point or may be moved through a pattern, while so directed, so as to form a moving crown which keeps away floating debris from around a given area, for example, from around a pier, or in front of a water intake, or away from an irrigation ditch.

WHAT WE CLAIM IS:—

1. A method of aerating water which comprises producing a current of water beneath the surface and introducing air taken from above the surface into the current thus produced, in which the rate at which the air is introduced into the current is maintained sufficiently low for the greater proportion of the air to be contained in the current of water as finely-divided bubbles of air which dissolve in the water to a substantial extent, and in which the current of water is produced in the form of an unconfined "shaft" of moving water taken from a point well below the surface of the water and no higher than the level at which the current is produced.

2. A method according to Claim 1, in which the direction of the current is changed intermittently or continuously.

3. A method acccording to Claim 1 or Claim 2, in which the current of water is directed in a generally horizontal plane.

4. A method according to Claim 1 or Claim 2, in which the current of water is directed towards the surface of the water.

5. A method according to any preceding claim, in which the current is swung to and fro over an arc of a circle.

6. Apparatus for carrying out the method of Claim 1 comprising an electric motor sealed against the entry of water and arranged to drive water-impelling means for producing a current of water in the form of an unconfined "shaft" of moving water when the said means and the motor are submerged, in which the water-impelling means have a pipe-connection to a float so that air can be drawn into the said means from the float at a sufficiently low rate for the greater proportion of the air to be contained in the current of water as finely-divided bubbles of air which dissolve in the water to a substantial extent, and in which the water-impelling means are arranged to draw water from a level no higher than that at which the water is impelled from the said means.

7. Apparatus according to Claim 6, in which the water-impelling means comprise a propeller driven by the motor.

8. Apparatus according to Claim 6, in whcih the water-impelling means comprise a water-pump having one or more delivery nozzles or outlets connected to its delivery side.

9. Apparatus according to any one of Claims 6—8, in which the water-impelling means are so constructed that the direction of the current of water produced by them can be changed.

10. Apparatus according to any one of Claims 6—9, in which the pipe-connection between the float and the water-impelling means contains a valve for controlling the passage of air through the pipe.

11. Apparatus for aerating water substantially as described with reference to Figures 1—3 or Figures 4 and 5 of the accompanying drawings.

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FIG. 1.

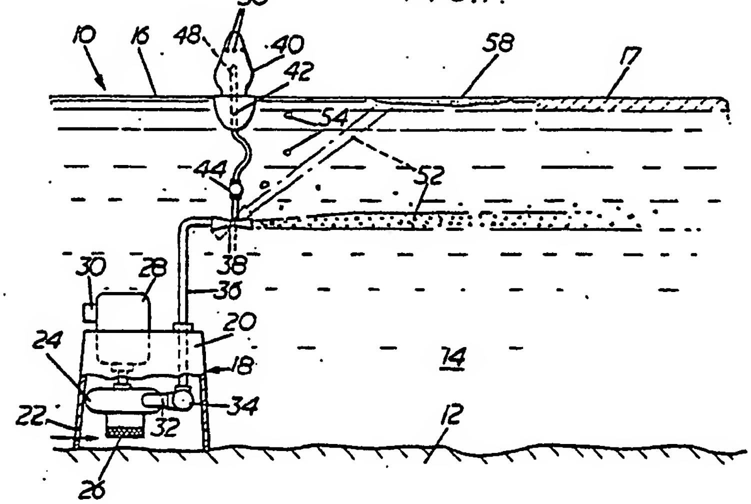


FIG. 3.

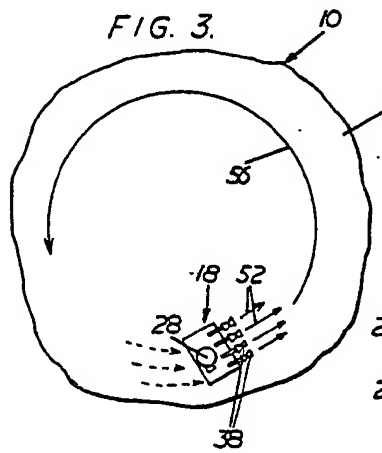
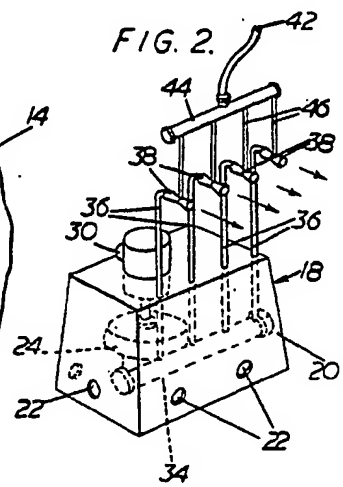


FIG. 2.



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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

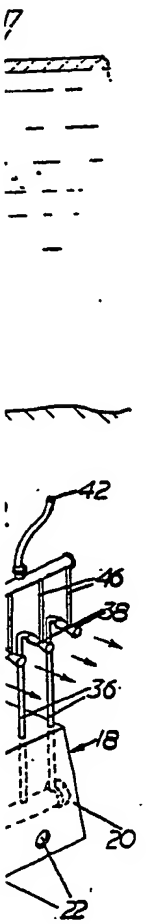


FIG.4.

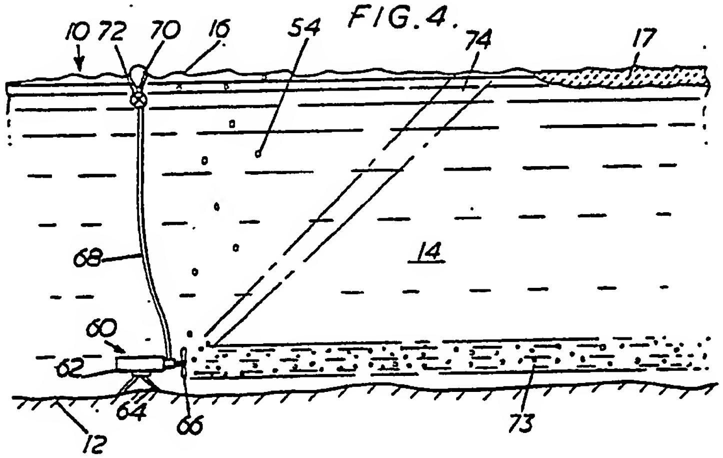
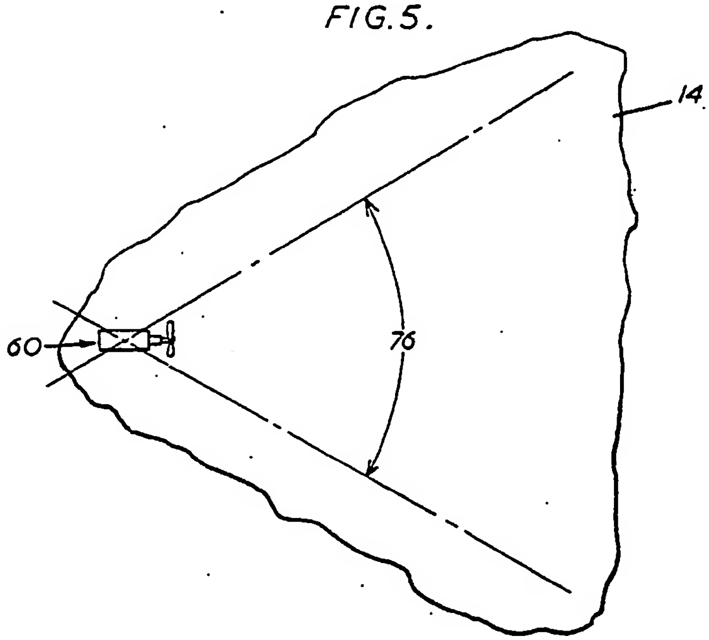


FIG.5.



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2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheets 1 & 2

FIG. 1.

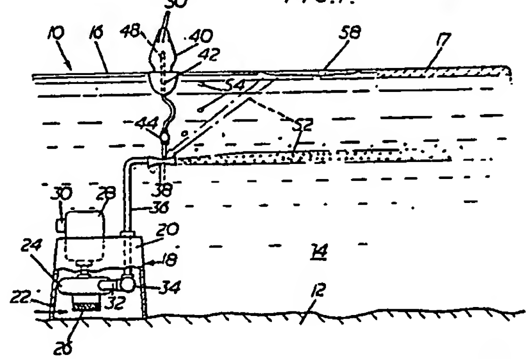

FIG. 4.

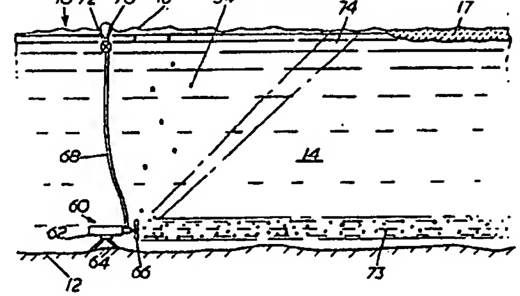

FIG. 3.

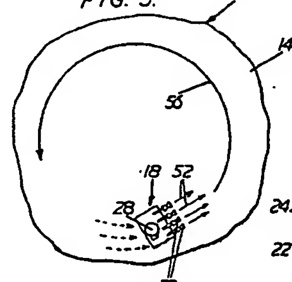

FIG. 2.

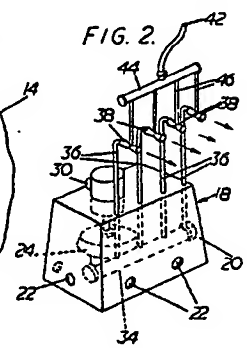

FIG. 5.